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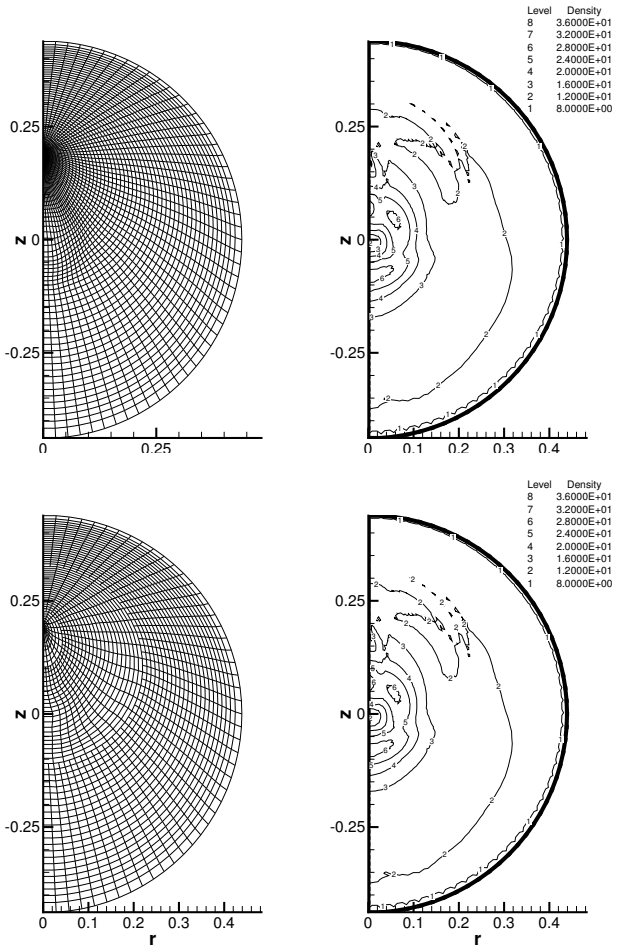
The Force/Work Differencing of Exceptional Points in Lagrangian Hydrodynamics

Raphael Loubere (T-7)
loubere@lanl.gov
Edward J. Caramana (CCS-2)
ejc@lanl.gov

This study presents the force and mass discretization of exceptional points in the compatible formulation of Lagrangian hydrodynamics. It concludes a series of papers that develop various aspects of the theoretical exposition and the operational implementation of this numerical algorithm. Exceptional points are grid points at the termination of lines internal to the computational domain, and where boundary conditions are therefore not applied. These points occur naturally in most applications in order to ameliorate spatial grid anisotropy, and consequent timestep reduction, that will otherwise arise for grids with highly tapered regions or a center of convergence. They have their velocity enslaved to that of neighboring points in order to prevent large excursions of the numerical solution about them. How this problem is treated is given herein for the aforemention numerical algorithm such that its salient conservation properties are retained. In doing so the subtle aspects of this algorithm that are due to the interleaving of spatial contours that occur with the use of a spatially-staggered-grid mesh are illuminated. These contours are utilized to define both forces and the work done by them, and are the central construct of this type of finite-volume differencing. Addtionally, difficulties that occur due to uncertainties in the specification of the artificial viscosity are explored, and point to the need for further research in this area.

The first pictures present the so-called Guderley problem in cylindrical geometry for a radial off-axes mesh with and without termination lines. The last pictures presents a straight piston (left boundary condition) sending a planar shock wave into a mesh with termination line with the original method and with the proposed treatment of termination lines. new method is



Guderley off axes problem at $t = 0.8$ with the tensor viscosity in cylindrical geometry - Top: Final mesh and density isolines - Bottom: Two termination layer mesh and density isolines with donation process.

Acknowledgements

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References

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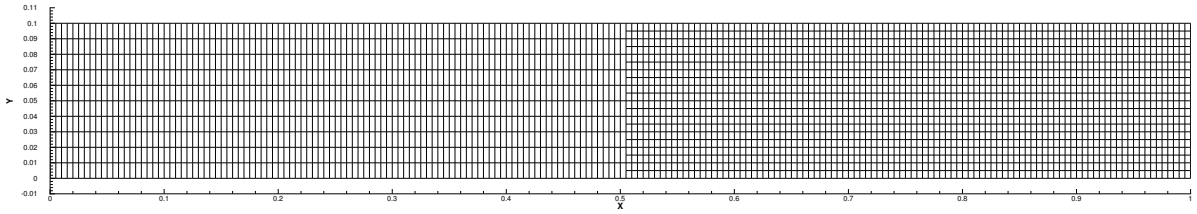
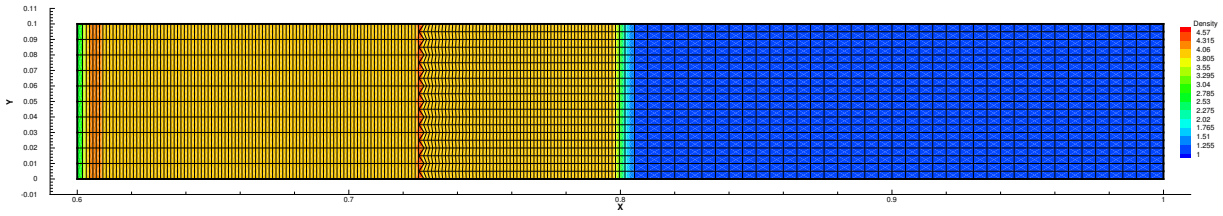
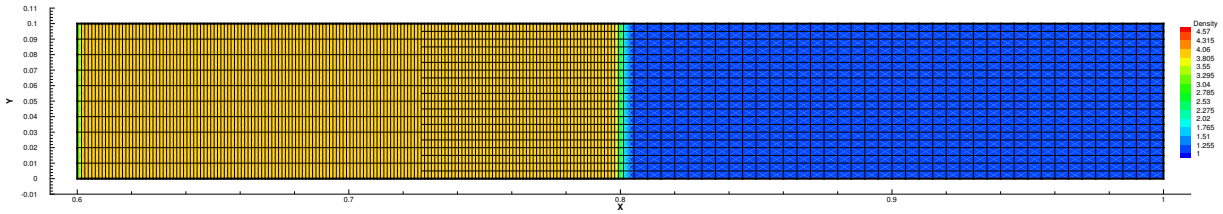


(a)



(b)



(c)

Straight piston (left boundary condition) with termination lines for the edge viscosity — Top: Initial mesh — Middle: Mesh and density at $t = 0.6$ original code — Bottom: mesh and density at $t = 0.6$ with donation. The donation treatment is designed to produce the same result as if no termination lines were used.

[1] E.J.Caramana, D.E.Burton, M.J.Shashkov, P.P.Whalen, "The Construction of Compatible Hydrodynamics Algorithms Utilizing Conservation of Total Energy", J. Comp. Phys. **146**, 227-262 (1998).

[2] E.J.Caramana, M.J.Shashkov, P.P.Whalen, "Formulations of Artificial Viscosity for Multi-Dimensional Shock Wave Computations", J. Comp. Phys. **144**, 70-97 (1998).